Timetable of Mk 56 Events

4/4/58	Assistant Secretary of Defense requests United States Atomic Energy Commission to cooperate in feasibility study of 330- and 550-pound warheads for the MINUTEMAN missile.
5/5/58	Feasibility study group recommends development of two warheads.
12/58	Division of Military Application reconvenes feasibility study group to consider a 600-pound warhead.
3/2/59	Feasibility study group reports that a suitable 600-pound warhead can be provided.

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9/15/59	Military Liaison Committee releases set of military characteristics for the MINUTEMAN warhead.

(b)(1), (b)(3)

11/20/59	Division of Military Application assigns development nomenclature of XW-56 and XW-56-X1 to the above designs.
12/24/59	Sandia issues development program definition of the XW-56 Warhead.

(b)(1), (b)(3)

8/60	Sandia publishes proposed ordnance characteristics of XW-56 Warhead.
10/13/60	Director of Defense Research and Engineering selects 600-pound XW-56-X1 design for MINUTEMAN.
12/1/60	Division of Military Application cancels XW-56 Warhead program. XW-56-X1 to continue and be called, in production, the Mk 56 Mod 1 Warhead.

3/24/61 Lawrence Radiation Laboratory and Sandia-Livermore forward development program definition of XW-56-X1 to Albuquerque Operations Office.

9/61 Production of XW-56-X1 Warhead authorized.

(b)(1), (b)(3)

12/18/62 XW-56-X2 Warhead interim development report accepted by Design Review and Acceptance Group.

3/63 Mk 56 Mod 1 Warhead final development report released. Early production attained.

(b)(1), (b)(3)

10/63 XW-56-X3 Warhead preliminary development report issued. Redesign provides hardening against weapon blast effects. (Produced Mod 2)

8/64 Early production of Mk 56 Mod 2.

9/64 Mk 56 Mod 1 supplement to final development report notes that the warhead safing system has been improved.

4/65 Mk 56 Mod 2 Warhead final development report released. Warhead hardened against blast effects.

3/66 Mk 56 Mod 2 supplement to final development report notes that the stockpile life of the neutron generator meets requirements of the military characteristics.

5/5/66 Division of Military Application requests hardening of warhead against effects of high-energy X-rays.

12/66 Design release of Mk 56 Mod 3 Warheads.

2/67	Early production of Mk 56 Mod 3 Warheads.
3/21/67	Sandia proposes additional hardening of warhead against X-rays.
5/24/67	Design release of Mk 56 Mod 4 Warheads.
5/67	Early production of Mk 56 Mod 4 Warheads.

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History of the Mk 56 Warhead

The Mk 56 was a program to provide a thermonuclear warhead for Weapon System WS-133A, whose vehicle was a three-stage, solid-propellant, intercontinental ballistic missile called MINUTEMAN, designed and manufactured by Boeing Airplane Company for the United States Air Force.

The MINUTEMAN missile was a second-generation system with more advanced characteristics than ATLAS and TITAN. A study group had suggested in 1956 that improvements could be made through the use of solid-propellant engines, which would reduce missile size, ground support equipment, numbers of operating personnel, and would increase missile readiness.

(b)(1), (b)(3)

The MINUTEMAN would be about 5-1/2 feet in diameter, 57 feet long, and weigh 65,000 pounds. It would be launched vertically from an unmanned, underground silo-type launcher, and missile stability provided by controlling the rocket nozzle direction.

(b)(1), (b)(3)

Development of the missile was approved by the Department of Defense February 28, 1958, and a study was released March 11, 1958.

This study indicated that two sizes of re-entry vehicles (and nuclear warheads) would be needed to achieve operational flexibility, and the Assistant Secretary of Defense, April 4, 1958, requested the United States Atomic Energy Commission

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to cooperate with the Department of Defense and the Air Force in a feasibility study of two MINUTEMAN warheads, one weighing in the neighborhood of 330 and the other 550 pounds. It was noted that these warheads would be required in large quantities. It was requested that the yields be the maximum achievable in the weights specified and that the systems have an operational deployment date of mid-1962.[1]

The feasibility study group met May 5, 1958 and, having been requested to quickly complete the task, finished the study in one day. It was felt that the lighter device could be developed as a modification of the Mk 50 NIKE ZEUS warhead of the Los Alamos Scientific Laboratory and that a heavier design could be provided by partial rework of the XW-47 POLARIS warhead of the University of California Radiation Laboratory. There appeared to be no unusual interprogram effects concerning application of either design to the MINUTEMAN missile, and it was felt that the operational deployment date could be met.[2]

Little action was taken during much of 1958, due to lack of MINUTEMAN funding.

(b)(1), (b)(3)

Results of this second feasibility study were published March 2, 1959. It was reported that the weight of the XW-47 could be reduced, and that several other Radiation Laboratory designs could be considered for an operational availability date of mid-1963. It was noted that the United States had suspended nuclear testing October 31, 1958 and, as a result, heavy emphasis was placed on designs that could be certified without full-scale test.[3]

The Air Force Special Weapons Center sent a teletype to Sandia March 15, 1959, noting that the Air Staff was considering possible acceleration of the MINUTEMAN program and requesting the earliest availability date of a MINUTEMAN warhead.[4] Sandia replied, March 20, 1959, stating that the most serious restraint on warhead availability would be the requirement for completion of a group of six successful missile-warhead flight tests about a year before the warhead could be stockpiled. If the XW-47 Warhead were used without change, these flight tests could be completed by December 1959, but if the warhead were modified. the flight tests might extend for another year.

(b)(1), (b)(3)

Subsequently the Joint Chiefs of Staff, August 5, 1959, established a requirement for a MINUTEMAN warhead with a diameter of 20 inches, length of 60 inches, weight of 600 pounds, and the highest yield obtainable within these parameters.

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AVCO Manufacturing Corporation would design and produce the re-entry vehicle.

(b)(1), (b)(3)

The Military Liaison Committee released a set of warhead military characteristics September 15, 1959. The weapon would provide air or ground burst, be sealed, and require a minimum of servicing and component replacement. It would be capable of being left unattended for long periods of time, and its storage life would be at least 3 years.

(b)(1), (b)(3)

The warhead would contain no primary source of power, unless the use of a ferro-magnetic X-unit became necessary. At least one arming device that would serve as a safety feature was required to sense the postlaunch environment, and this component would be installed in the warhead so as to minimize the possibility of nuclear detonation by sabotage.[3]

The following priorities would be observed: Safety from nuclear disaster to friendly installations, acceptable reliability, operational simplicity, ease of maintenance, and invulnerability to ~~neutron radiation~~ nuclear countermeasures. If the warhead system were such that, when armed, energy was stored awaiting a firing signal for detonation, a device would be required to safely dissipate the energy in a minimum time, not over 10 minutes, and not to interfere with the normal arming/firing sequence.

(b)(3)

The Division of Military Application, in forwarding the development request, suggested that the program be assigned to the Lawrence Radiation Laboratory.[7]

(b)(1), (b)(3)

If this test proved successful, weaponization would be completed in about another 2 years. It was felt that sufficient confidence in the design might be generated to warrant its stockpiling without full-scale detonation.

(b)(1), (b)(3)

Lawrence Radiation Laboratory and Sandia-Livermore notified the Division of Military Application, October 29, 1959, that in view of the existing heavy weapon work load, it was important that the MINUTEMAN warhead be scheduled no earlier than required by missile production. The desired date appeared feasible, but its accomplishment would depend on the schedule set by the re-entry vehicle program.

(b)(1), (b)(3)

Sandia issued a development program definition for the XW-56 December 24, 1959.[11]

(b)(1), (b)(3)

The nonnuclear components of the XW-56 would weigh less than those of the XW-47, and it was felt that the gross warhead weight would be about 670 pounds. (b)(1), (b)(3)

(b)(1), (b)(3)

The 16 flight tests required would start about May 1961 and furnish structural, environmental and systems operational data. Pilot-production release was scheduled for early 1961, with complete engineering release by the middle of the year. Early production would be achieved by mid-1962.

The firing system would contain an inertial generator, X-unit and environmental sensing devices, with a ferromagnetic design as alternate. The warhead would not be structurally integrated with the re-entry vehicle, but would be supported ~~near the warhead midpoint. This type of support would simplify the missile interface problems.~~

(b)(3)

The MINUTEMAN missile had a diameter of ~~8~~ 5.5 feet, length of 58 feet, launch weight of 65,000 pounds, re-entry vehicle weight of 915 pounds, range of 2,000 to 5,500 nautical miles, maximum velocity of 24,000 feet per second, impact velocity of 600 to 800 feet per second, and a three-stage solid-fuel propulsion system. Launching facilities included a fixed underground silo complex or a mobile platform.

No new materials would be required by the program, and all weapon components were used in other projects.

(b)(1), (b)(3)

The Division of Military Application sent a teletype to Albuquerque Operations Office May 2, 1960, proposing three possibilities for warhead development.

(b)(1), (b)(3)

Sandia-Livermore was asked whether development of the modified XW-56 would delay the operational availability date of June 1962, and the Division of Military Application was informed that design was in progress and that the date would be met.[15]

By May 1960 a decision was made to use a ferromagnetic transducer in the XW-56 system. It would be necessary to include diodes in the arming and surface-burst fire lines for isolation. Due to current requirements, silicon rectifier diodes appeared to be the only practical type, and development was under way on an arming-line diode that could handle surge currents and have sufficient resistance to radiation.[16]

A decision had been made to use fuse-actuated switches. Four of these would be mounted on a printed circuit board and packaged in a switch pack, with two switches protecting exciting-current input lines to the ferromagnetic transducer and two others protecting fire-signal input lines. Closure of the switches in the current input lines would provide one of the two required independent arming signals.[17]

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(b)(1), (b)(3)

Field Command noted that there was no apparent advantage to a mixed arsenal of tested and untested warheads, as the best design should be selected. The Radiation Laboratory saw some benefit in a mix of lower-weight, lower-yield tested warheads for the XW-56 until the XW-56-X1 design became available, as the reduced weight would extend the range of the MINUTEMAN to more targets.

At the request of the Division of Military Application, the Radiation Laboratory provided additional information August 25, 1960.

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(b)(1), (b)(3)

Field Command, in a teletype to Sandia September 7, 1960, noted that it would be at least theoretically possible to design a weapon containing a Los Alamos primary and a Radiation Laboratory secondary.

(b)(1), (b)(3)

Meanwhile, Sandia had originated Report SC4819(WD), Proposed Ordnance Characteristics of the XW-56 Warhead.

(b)(1), (b)(3)

The report stated that early mechanical interface designs included various forward and rear supports of the warhead. The design was changed to a single mechanical interface flange, which provided a cantilevered support of the warhead in re-entry vehicle and avoided differential thermal expansion problems between warhead and re-entry vehicle structure.

The warhead would have an explosive ferromagnetic transducer. The system would contain dual arming and firing circuits, and environmental sensing devices would prevent inadvertent signals from activating the warhead. The system would detonate the weapon by either air-burst or contact-burst firing signals supplied by the re-entry vehicle arming and fuzing package.[23]

Field Command notified Sandia, September 23, 1960 that the ordnance characteristics report had been reviewed in coordination with representatives of the three Services. The report noted that the use of a reversible arm/safe operation solely for the purpose of receiving power and/or signals for safing appeared to be neither practical nor feasible. Additionally, in view of recent warhead design changes, no firm time interval for full arming could be established. Both these conditions were accepted, and the review established that the design met all requirements of the approved military characteristics. However, it was requested that positive means be provided to prevent transfer of boosting gas into the pit in event of external fire.[24]

The Director of Defense Research and Engineering, in a letter dated October 13, 1960, approved the 600-pound XW-56-X1 design for the MINUTEMAN warhead.[13]

(b)(1), (b)(3)

(b)(1), (b)(3)

An operational availability date of July 1, 1962 was requested for a normal-version warhead, as well as a maximum-yield 600-pound warhead with an availability date of July 1963.

(b)(1), (b)(3)

This latter design would have the maximum yield possible without nuclear test and would be compatible with advanced design re-entry vehicles.

(b)(1), (b)(3)

The XW-56-X1 would be called, in production, the Mk 56 Mod 1 Warhead.[28]

Lawrence Radiation Laboratory and Sandia-Livermore forwarded the development program definition of the XW-56-X1 to Albuquerque Operations Office March 24, 1961. A series of 10 warhead flight tests would start by July 1962. Engineering release was planned for mid-1962 and early production for May 1963.

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(b)(1), (b)(3)

Environmental safing devices would provide warhead safety before the warhead was mated to the arming/fuzing package. The warhead would be sealed. A single flange would be provided for attachment to the re-entry vehicle structure.

(b)(1), (b)(3)

No materials or components were expected to present any unusual procurement or manufacturing problems.[29]

In June 1961 the Division of Military Application requested operational availability by April 1963, and it was agreed that, with increased effort, this date could be met.[30] In September 1961 Albuquerque Operations Office requested a first-production-unit date of February 1963 and increased quantities of warheads in the early months of production.[31] The difficulties in supporting such effort were discussed, and this additional acceleration was canceled. Production was authorized in September 1961 and the Division of Military Application subsequently notified the Military Liaison Committee that early units would be available by March 1963.[32]

(b)(1), (b)(3)

The design was accordingly

changed, January 18, 1962, to use external initiators and a chopper-converter firing set.[33] The XW-56-X1 was redesignated XW-56-X2, but retained production nomenclature of Mk 56 Mod 1.[34]

(b)(1), (b)(3)

The Mk 56 Mod 1 Warhead was design-released in May 1962.

(b)(1), (b)(3)

The report was accepted by the Design Review and Acceptance Group December 18, 1962.[37]

Previously, Sandia-Livermore had notified Albuquerque Operations Office that a reasonable degree of radiation hardening could be accomplished with little effect on the yield, weight and operational availability date. Existing hardening methods would, however, impose limitations on low-temperature, long-term storage, and techniques to avoid this limitation were under study.

(b)(1), (b)(3)

Sandia-Livermore sent a teletype to the Division of Military Application December 20, 1962, noting that efforts had been made to increase the resistance of the warhead to blast effects produced by antimissile defense systems and stating that the method of mating warhead to re-entry vehicle would be changed. Instead of a single-flange cantilevered mounting system, paper honeycomb would be placed between warhead and re-entry vehicle to provide area loading.

This design change would be called the XW-56-X3 and would become, in production, the Mk 56 Mod 2. The design-release date would be July 1963.[40]

(b)(1), (b)(3)

The Mk 56 Mod 2 would not be interchangeable with Mk 56 Mod 1, and early production was scheduled for April 1964.[41]

Report SC4868(WD), Mk 56 Mod 1 Warhead Final Development Report, was issued March 1963. This noted that early production had been accomplished. The Mk 56 Mod 1 Warhead was 17.4 inches in principal diameter, 47.3 inches long, weighed 600 pounds, and was compatible with the Mk 11 re-entry vehicle.

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The electrical system had two parallel arming and firing channels. Since some of the components operated irreversibly, the signals had to be given in proper motor. The transformer secondary was connected to storage capacitor and neutron generators through a voltage regulator.

(b)(3)

The warhead could be detonated by either air-burst or surface-burst signal. The signal was produced by the arming/fuzing system and operated a puncture switch, which discharged the storage capacitors through the warhead detonators. Output from this puncture switch also actuated the neutron generators, assuring an ample supply of neutrons at nuclear detonation time.[42]

(b)(1), (b)(3)

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Report SC4869(WD), XW-56-X3 Warhead Preliminary Development Report, was issued October 1963. This noted that the warhead would be used with the Air Force's Mk 11A re-entry vehicle system, and would provide interim hardening against blast effects. Early production was scheduled for April 1964 and the warhead would be called the Mk 56 Mod 2.

The XW-56-X3 Warhead included major portions of the Mk 11 reentry vehicle and was 32 inches in maximum diameter, 80.5 inches long, and weighed 831 pounds.

(b)(1), (b)(3)

With minor exceptions, the warhead electrical system was unchanged. Inertial switches were redesigned, as early designs could not withstand high loads. These inertial switches were incorporated in the firing set and the firing set redesignated. The neutron generator was also redesignated, due to a change in mounting. Design release was accomplished in July 1963.[46] The report was presented to and accepted by the Design Review and Acceptance Group, and forwarded to the Division of Military Application October 31, 1963.[47]

Sandia-Livermore, in a letter dated May 20, 1966, noted that a program to harden the Mk 56 Mod 2/Mk 11A against hot (high energy) X-rays had been proposed by the Ballistic Systems Division of the Air Force Systems Command.

(b)(1), (b)(3)

The Division of Military Application, May 5, 1966, requested that the nuclear laboratories provide design support for the X-ray hardening program, and an analysis was completed and forwarded June 28, 1966.

(b)(1), (b)(3)

The forward shield that interfaced with Sandia components and the nuclear package would be designed by Sandia-Livermore. Sandia was planning design release by October 1966, with deliveries of production weapons by March 1967. The design would be called the XW-56-X4, with production nomenclature of Mk 56 Mod 3. Existing Mk 56 Mod 2 Warheads would be retrofitted with the new design.[53] Subsequently, however, delays were encountered in missile deliveries, and the design release was deferred to December 1966 and early production to February 1967.[54]

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Glossary of Mk 56 Terms

(b)(1), (b)(3)

Ballistic Missile -- Long-range missile given a high initial velocity and which travels on a ballistic course to the target.

Boosting Gas -- Deuterium-tritium gas introduced into the implosion process to increase the fission activity and thus the yield of the device.

Bridge Wires -- Low-resistance wires in the detonators (which see) which explode when subjected to high-voltage pulse from the weapon X-unit, and thus ignite the explosive elements of the detonator.

Capacitor -- A condenser that accumulates and stores electrical energy until time for detonation.

Chopper-Converter -- A device for transforming steady direct current into chopped pulses of energy.

<u>Contact Fuze</u> -- A fuze that detonates the weapon by contact with the ground or the target.

<u>Defense Atomic Support Agency</u> -- An interdepartmental agency formed to handle military functions related to atomic weapons. Originally called the Armed Forces Special Weapons Project.

<u>Department of Defense</u> -- The Armed Forces, i.e., the Army, Navy and Air Force.

<u>Depleted Uranium</u> -- Natural uranium from which most of the uranium-235 has been removed, leaving the uranium-238.

<u>Design Review and Acceptance Group</u> -- A Military committee established to review the design of a specific weapon.

<u>Detonators</u> -- Explosive devices which, when initiated (see bridge wires) by the X-unit, ignite the lens charges of the high-explosive sphere (which see).

<u>Deuterium</u> -- The hydrogen isotope of mass number 2.

<u>Development Program Definition</u> -- A report that describes the weapon to be designed and the steps that will be taken in its development.

<u>Director of Defense Research and Engineering</u> -- Change of name for the Assistant Secretary of Defense.

<u>Division of Military Application</u> -- An AEC office that functions as liaison between the Military and weapons designers and producers.

<u>Dominic</u> -- A full-scale test operation held in the Pacific. Series of 39 tests, April 25 to November 4, 1962. Dominic was authorized after the test ban was broken by the Soviet Union in 1961.

(b)(1), (b)(3)

<u>Field Command</u> -- The local office of the Armed Forces Special Weapons Project (Defense Atomic Support Agency), located on Sandia Base, Albuquerque, New Mexico.

<u>Firing System</u> -- The electrical system of the weapon that produces and applies a high-voltage current to the detonators.

Kilogram -- A metric weight approximating 2.2 pounds.

Kiloton -- A means of measuring the yield of an atomic device by comparing its output with the effect of an explosion of TNT. A 1-kiloton yield is equivalent to the detonation effect of 1000 tons of high explosive.

Lawrence Radiation Laboratory -- A change of name for the University of California Radiation Laboratory (which see), effective October 1958.

Los Alamos Scientific Laboratory -- A nuclear design organization located at Los Alamos, New Mexico.

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One-Point Safe Weapon -- A weapon that will not produce a nuclear yield when detonated at one point on the surface of the high explosive.

Operation Dominic -- See Dominic.

Operation Hardtack -- See Hardtack.

Operation Nougat -- See Nougat.

(b)(3)

Re-entry Vehicle -- That part of a ballistic missile that forms the nose of the missile, generally contains the warhead, and is detached from the missile during the trajectory to re-enter the earth's atmosphere and follow a ballistic trajectory toward the target.

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(b)(1), (b)(3)

University of California Radiation Laboratory -- A laboratory established at Livermore, California. Initially founded for work on thermonuclear designs.

Uranium-235 -- A radioactive element, an isotope of uranium-238.

Uranium-238 -- A radioactive element, atomic number 92. Natural uranium contains about 99.3-percent uranium-238; the rest is uranium-235.

Warhead -- A weapon carried to the target by missile.

X-Unit -- A device used to provide high voltage to the weapon detonators.

Yield -- The measure of the effect of a nuclear detonation compared to the effect of an explosion of TNT.

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